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WASTES INTO PRODUCTION

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CONSTRUCTION GLASS MATERIAL BASED ON ASH FROM WASTE INCINERATION PLANTS

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It is shown that it is possible and expedient to use ash from waste incineration plants as a component for batch (ash content to 70%) in the production of glass materials to be used in construction.

Key words: ash from waste incineration plant, glass material, batch, production of construction material.

The problem of processing solid domestic wastes (SDW) has reached an acute point. The amount of such wastes is increasing unabatedly, cluttering an enormous territory and degrading the environment. Their disposal is one of the most important measures for protecting the environment. The futility and danger of the method of disposal was recognized a long time age, and considerable efforts are being made to reduce the size of landfills.

Four processing methods are widely used in world practice: incineration, biothermal composting, anaerobic fermentation and sorting. Each method has its own advantages and disadvantages and its own optimal areas of application depending on the composition of the wastes and regional conditions. For economic or technical reasons the method of burning in waste incineration plants (WIP) is the main method used for the disposal of SDW which are not undergo secondary processing.

The main advantages of the thermal method of disposal are:

– the mass of the wastes is reduced by more than 70% and the volume by more than 90%;

– heat and electricity are obtained;

– dangerous wastes (specifically, medical) can be eliminated [1].

The incineration of SDW results in the production of ash slag byproducts. Ordinarily, they are placed in landfills, which become a source for the contamination of the soil, atmosphere and ground water.

The WIP wastes — ash and slag — comprise complex mineral compositions which have a silicate base with large fluctuations in the content of the main components, which depend on the composition of the SDW, the design and size of the furnace and the pressure and distribution of the air fed into the furnace. From 15 to 20 t ash are formed in a single waste incineration furnace in one day. The chemical composition of the wastes generated by waste incineration is presented in Table 1 [2].

Ash is a grey, dust-like, inorganic substance differing in chemical composition from slag by higher content of $K_2O + Na_2O$ and $CaO + MgO$. In addition, ash contains water soluble trace impurities in the form of lead, zinc, mercury, cadmium and fluoride salts in amounts an order of magnitude higher than in slag. All this impedes its use in the production of building materials which have high water absorp-

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TABLE 1. Chemical Composition of the Wastes

Wastes from WIP	Oxide content, wt.%								
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O	SO_3
Ash	26.0 – 40.6	7.3 – 10.8	2.5 – 6.2	0.5 – 2.3	15.0 – 20.6	2.8 – 4.1	1.7 – 8.3	1.2 – 8.2	5.7 – 1.7
Slag	39.6 – 69.7	6.2 – 14.3	3.5 – 11.2	0.5 – 0.9	9.5 – 15.1	1.6 – 3.2	1.2 – 4.5	1.2 – 2.6	0.7 – 6.4

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TABLE 2. Chemical Composition of the Synthesized Glasses

Glass composition No.	Oxide content, wt.%									
	SiO_2	Al_2O_3	CaO	$Na_2O + K_2O$	TiO_2	Fe_2O_3	MgO	MnO	P_2O_3	SO_3
1	50.00	2.68	19.52	5.81	0.46	0.65	2.54	0.020	0.60	1.86
2	49.99	3.15	22.81	5.59	0.54	0.76	2.61	0.024	0.72	2.23
3	49.97	3.40	24.44	5.52	0.58	0.82	2.66	0.026	0.78	2.42
4	49.95	3.65	26.08	4.98	0.63	0.88	2.70	0.028	0.84	2.60

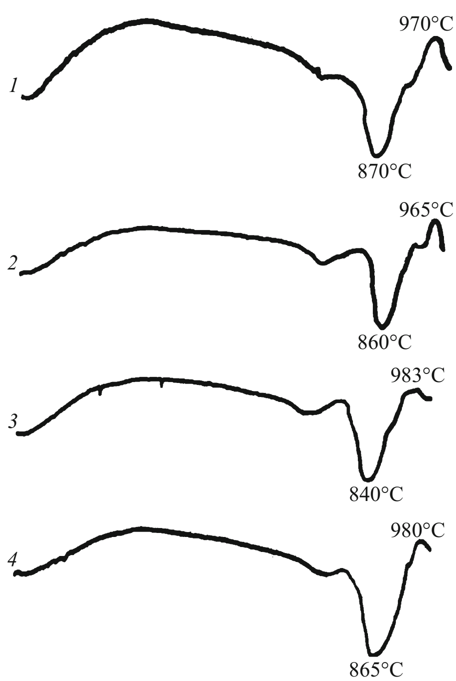

Fig. 1. DTA curves of glasses based on ash from a waste incineration plant (the numbers on the curves correspond to the composition of the synthesized glasses).

tion and low chemical stability. From the standpoint of sanitary-hygienic norms glass, possessing a nonporous structure and a tightly bound silicon-oxygen framework in whose structure heavy-metal ions participate in a high-coordination state, provides chemical resistance against the surrounding medium and aggressive reagents. The conversion of glass into a glass ceramic state opens up additional possibilities for increasing the operational reliability of material based on ash from WIP.

The closeness of the compositions of ash from WIP to the chemical composition of commercial glasses and the high dispersity, which imparts high reactivity, make them promising components of raw-material mixtures for synthetic glass and glass ceramic materials for construction.

In the present work ash from the special plant No. 2 at the State Unitary Enterprise Ékotekhprom was used. To decrease the effect of fluctuations in the chemical composition the ash was blended by repeated mixing of different batches. The experimental samples were prepared from ash with the following chemical composition[3] (%): 13.1 SiO_2, 5.04 Al_2O_3, 33.7 CaO, 4.39 ($Na_2O + K_2O$), 1.17 Fe_2O_3, 1.48 MgO, 0.04 MnO, 1.20 P_2O_5, 0.85 TiO_2 and 29.4 other.

The region bounded by the isolines 75% SiO_2, 15% CaO and 10% Al_2O_3 in the phase diagram SiO_2–Al_2O_3–CaO was chosen to develop compositions for making glass. The choice of glass compositions was determined by, first and foremost, the quite high percentage content of ash from WIP in the batch — the amount of ash varied from 50 to 70%. To realize the glass-formation process quartz sand and soda were added (with WIP ash content in the batch 50, 60, 65 and 70%).

The glass was made in a gas furnace at temperature 1550 ± 10°C with soaking for 35 – 40 min. Samples with the required dimensions were poured from the melt and fired at 560 – 570°C for 1 h. The glasses obtained did not contain nonuniform inclusions, batch stones or bubbles and were black, which was due to the presence of Fe and Mn sulfides. No corrosion of the crucibles at the level of the surface of the molten glass was observed, whence it follows that the melts are nonaggressive. The compositions of the glasses obtained are presented in Table 2.

The main physical-chemical properties of the synthesized glasses (determined by standard procedures) are presented in Table 3.

On the whole the properties of the glasses obtained meet the specifications for glass facing tile (TU-21 RSFSR-403–80).

TABLE 3. Properties of the Synthesized Glasses

Glass composition No.	Density, kg/m^3	CLTE, 10^{-7} K^{-1}	Temperature resistance, °C	Ultimate tensile strength, MPa	Microhardness, MPa	Chemical stability
1	2676	91.7	105	85.4	5810	II
2	2662	90.3	110	87.4	6140	II
3	2696	90.1	115	88.0	6490	II
4	2714	89.5	120	88.5	5790	II

[3] Here and below, content by weight, %.

The possibility of forming molten glass from the standpoint of crystallizability was evaluated by a crystallization index calculated from the relation

$$-\Delta T = T_{\text{ulc}} - T_{\text{f}},$$

where ΔT is the crystallization index, T_{ulc} is the temperature of the upper limit of crystallization (ULC) and T_{f} is the formation temperature.

The possibility of forming articles is determined by the condition according to which glasses characterized by a negative index ΔT are suitable for making glass. Thus, if the upper limit of crystallization of the melt corresponds to approximately 1070°C and $\Delta T = -70$°C, then $T_{\text{f}} = T_{\text{ulc}} + \Delta T =$ 1140°C. The DTA method was used to evaluate the crystallizability of the synthesized glasses. In all thermograms (see Fig. 1) endo effects are observed at 170°C, which are associated with the removal of residual moisture due to the very high dispersity of the glass powder, and small endo effects are observed in the temperature range 680 – 700°C, which are correspond to the onset of deformation. The low, extended peaks on the DTA curves indicate that surface crystallization makes a significant contribution. The exo peak at temperatures 960 – 983°C is extended and lies in a narrow temperature range, which probably indicates volume crystallization.

It was determined from x-ray phase analysis that the phase composition of all four crystallized samples is practically identical and represented mainly by wollastonite $CaSiO_3$ with the entry of Na, Al and Mg cations, which form solid solutions, expressed by the presence of doublets and triplets in the x-ray diffraction patterns.

It can be concluded on the basis of the data obtained that all four compositions of the experimental glasses obtained correspond to materials whose physical-chemical and mechanical properties meet the specifications for facing building materials.

In summary, it was shown that ash from waste incineration plants can be used effectively in batch for the production of glass ceramic articles for use in construction. This will make it possible to reduce considerably the consumption of raw materials as well as to contribute to the solution of the environmental problem of the disposal of ash from waste incineration plants.

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